Brain Computer Interfaces

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Coma Victim Has a Voice After 23 Years
Coma Victim Has a Voice After 23 Years
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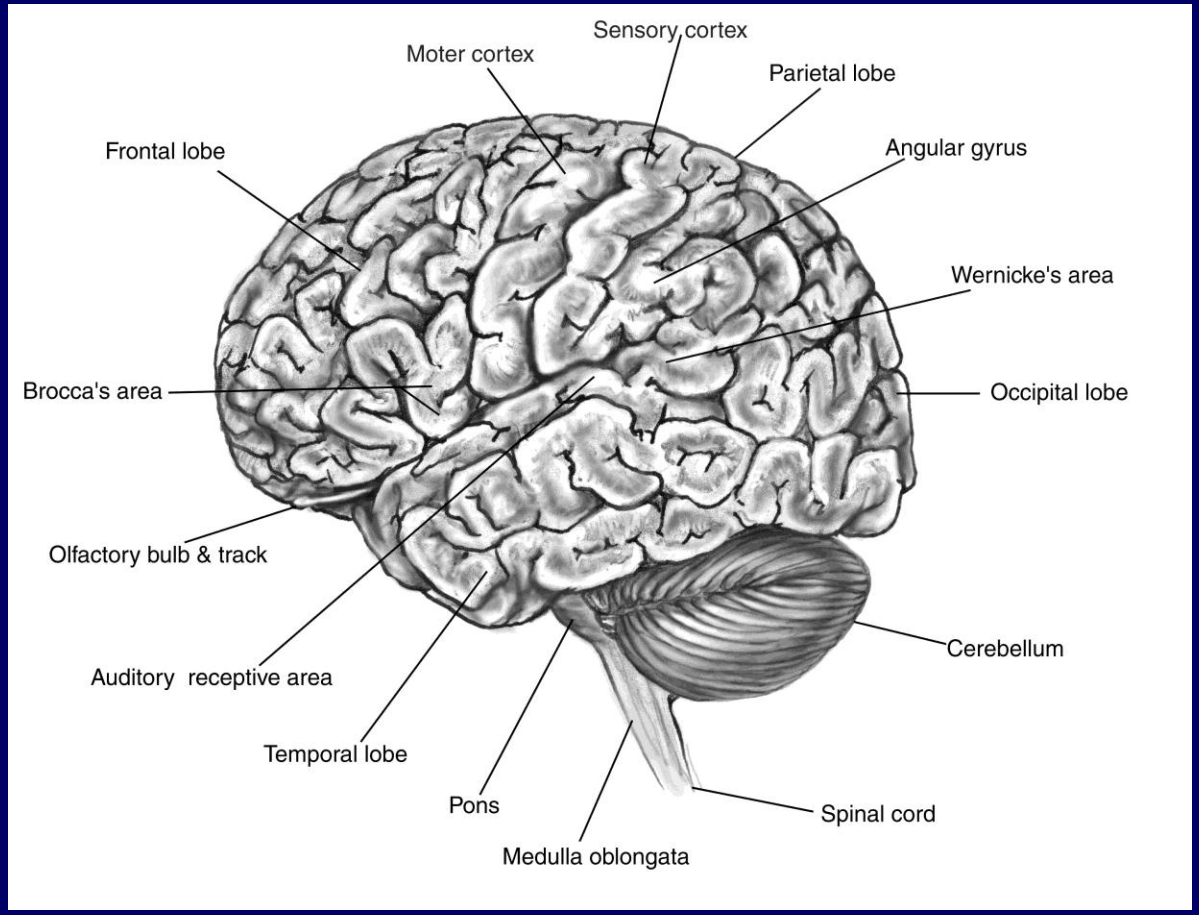
Structure of Brain

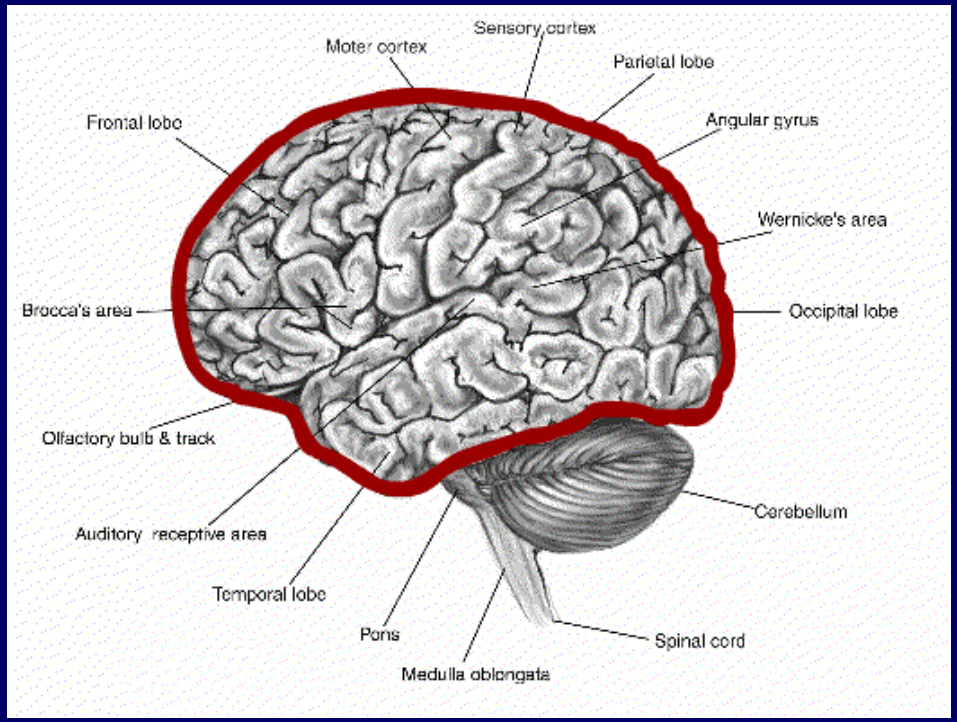


Brain

1. Cerebrum
2. Cerebellum
3. Brainstem

Cerebrum

- The cerebrum is the section where thoughts are created and memory is stored.
- Injury to the cerebrum can leave a person fully aware of their surroundings but unable to react to any events happening in the surroundings

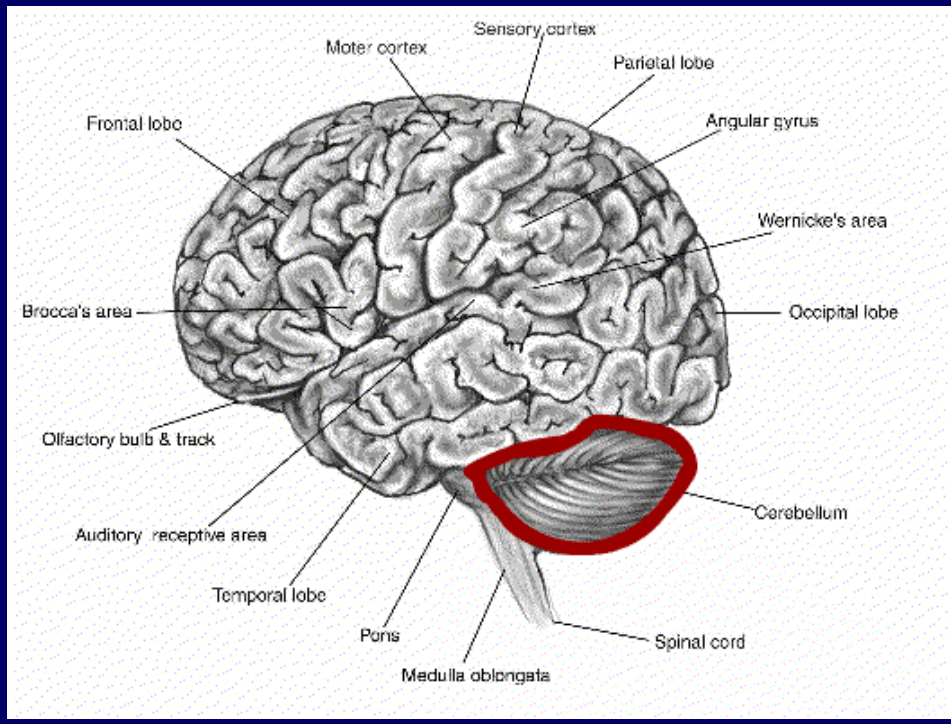


Lobes of Cerebrum

- The cerebrum also has five lobes:
  - **Frontal lobe:** motor cortex, which creates alpha brain waves
  - **Occipital lobe:** visual cortex that effects the visual perception
  - **Temporal lobe:** contains the cranial nerve and auditory cortex, damage can result in deafness
  - **Parietal lobe:** primary somatosensory cortex. Damage to this area of the brain affects the ability to use bio-potentials to manipulate a Brain-Body Interface
  - **Insular lobe:** affects emotion and damage to this region may affect a person's ability to relax

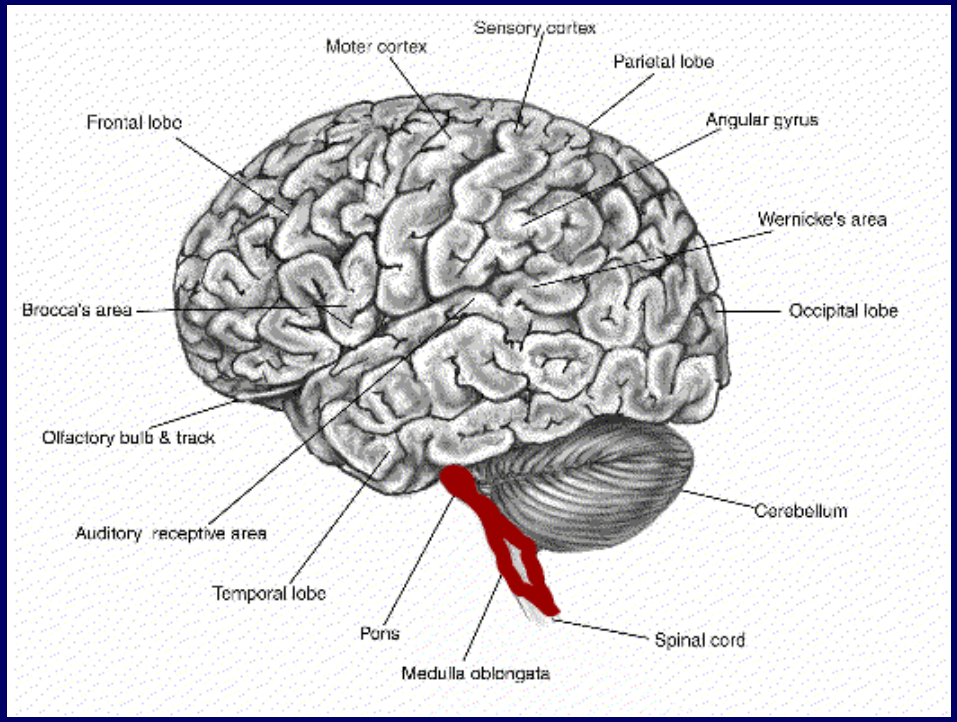
Cerebellum

- Controls facial muscle co-ordination
- Damage to this area affects the ability to control eye movements and other facial muscle movements
- Will affect signals needed by Brain-Body Interfaces



Brainstem

- Controls basic functions such as eating, respiration, heart rate
- The cranial nerves that carry the signals to control facial movements originate in the brainstem



Bio-Potentials

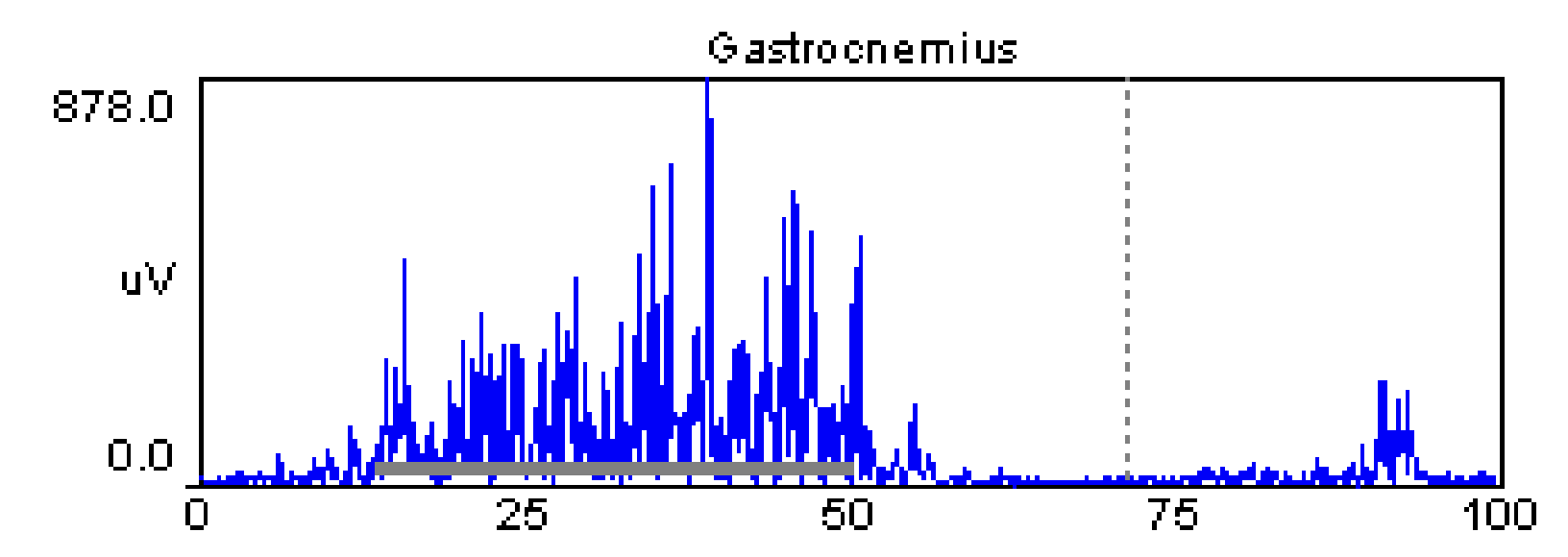
- Electroencephalalography (EEG) - amplitude can vary between 10 - 100 µV when measured on the scalp or forehead, covers a frequency spectrum of 1 - 30 Hz and is divided into five classes.
- Electromyography (EMG) - 18 Hz, signals have an amplitude range of 0.2 - 2000 µV.
- Electrooculargraphy (EOG) - 1.1 - 6.25 Hz, signals have an amplitude range of 1 - 4 mV.
- Slow Cortical Potentials (SCP) - frequency range 1 - 2 Hz, can be positive or negative, signals can be 5 - 8 µV
- Steady-State Visual Evoked Potential (SSVEP)/ Steady State Visual Evoked Responses (SSVER) - uses the 4 to 35 Hz frequency range, transfers data at high data transfer rates (68 bits/s) and occur at 100 - 1000 ms after the stimuli.

Bio-Potentials

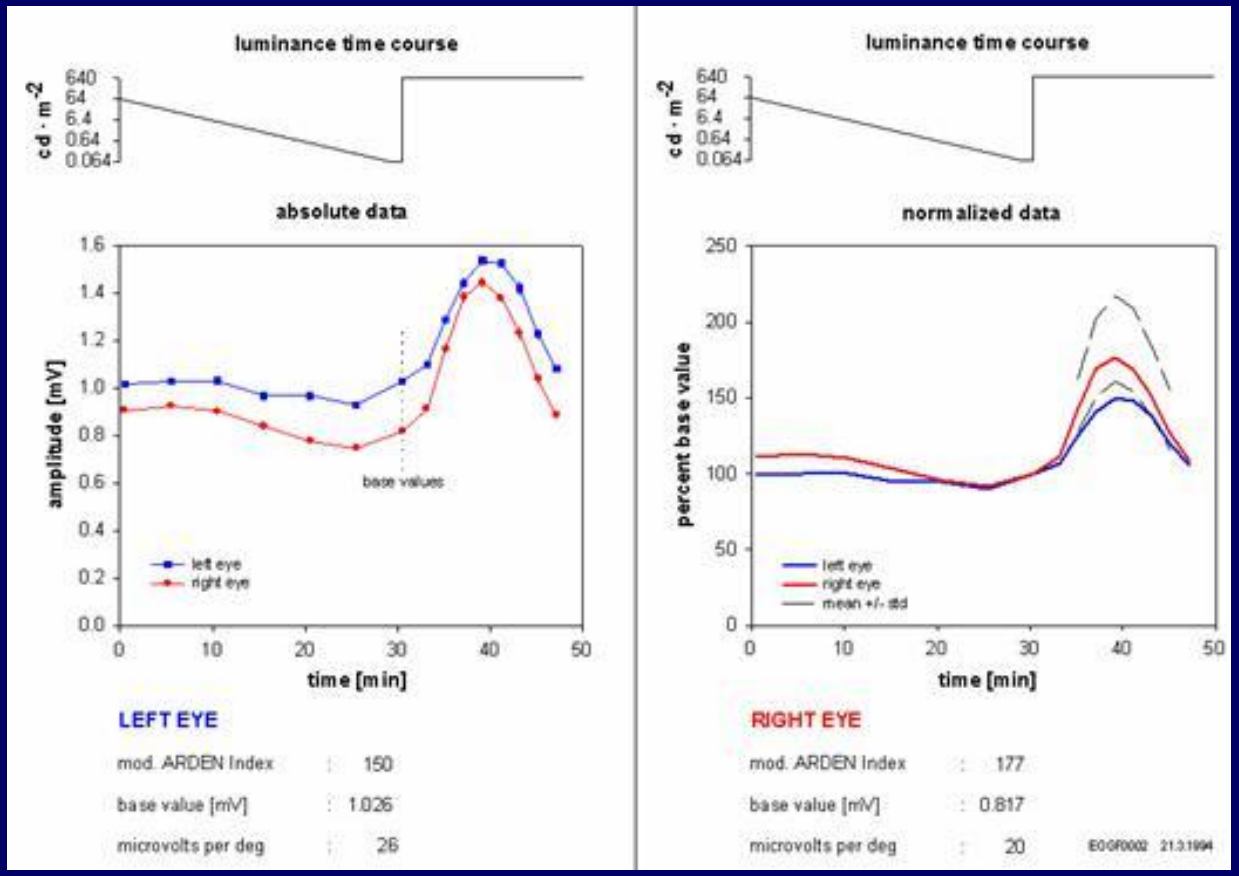
- P300 - displays a brain wave with positive amplitude, peaking at around 300 ms after task-relevant stimuli. This signal occurs in the delta (0.5 - 4 Hz) and theta (4 - 7 Hz) frequency range.
- N400 - displays a brain wave with negative amplitude, peaking at around 400 ms triggered by unexpected linguistic stimuli.
- Electrocochleography (ECoG) - - 300 - 1000 μV amplitude and has a frequency of 40 Hz
- Low Frequency Asynchronous Switch Design (LF-ASD) - signals in the 1 - 4 Hz frequency range, with an amplitude of 10 - 100 μV.
- Local Field Potential (LFP) - synchronous oscillations in the 15 - 30 Hz frequency range and have an amplitude of 6 μV.
- Neuroprosthetic
- Motor Function

Electroencephalography (EEG)

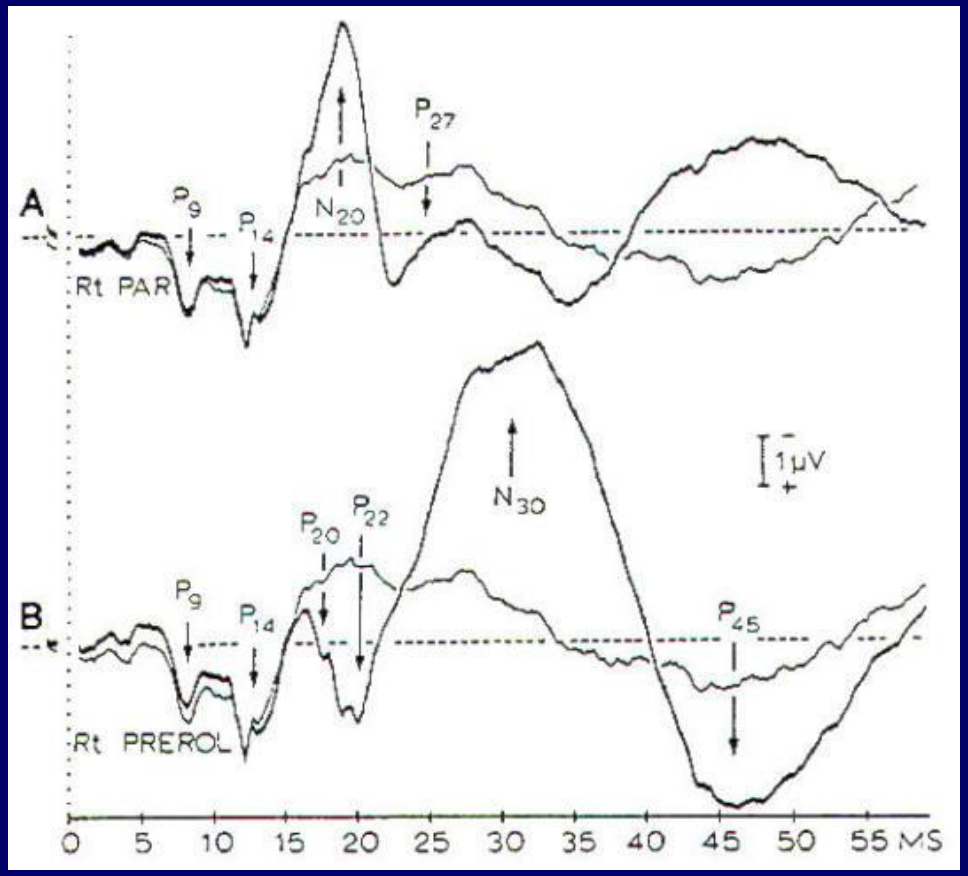
Electromyography (EMG)



Electrooculargraphy (EOG)



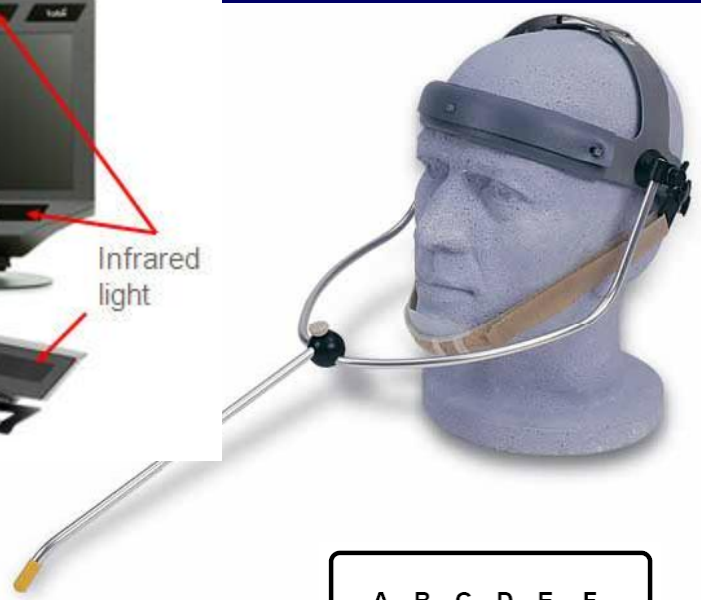
P and N signals

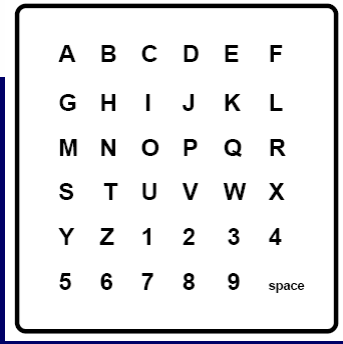


Brain Body Interfaces – Examples (these need some control movement above the neck)

- HeadMouse™
- Tonguepoint™
- Eye-tracking
- Thought Translation Device

Many brain-injured are so impaired that they cannot use any devices in this category



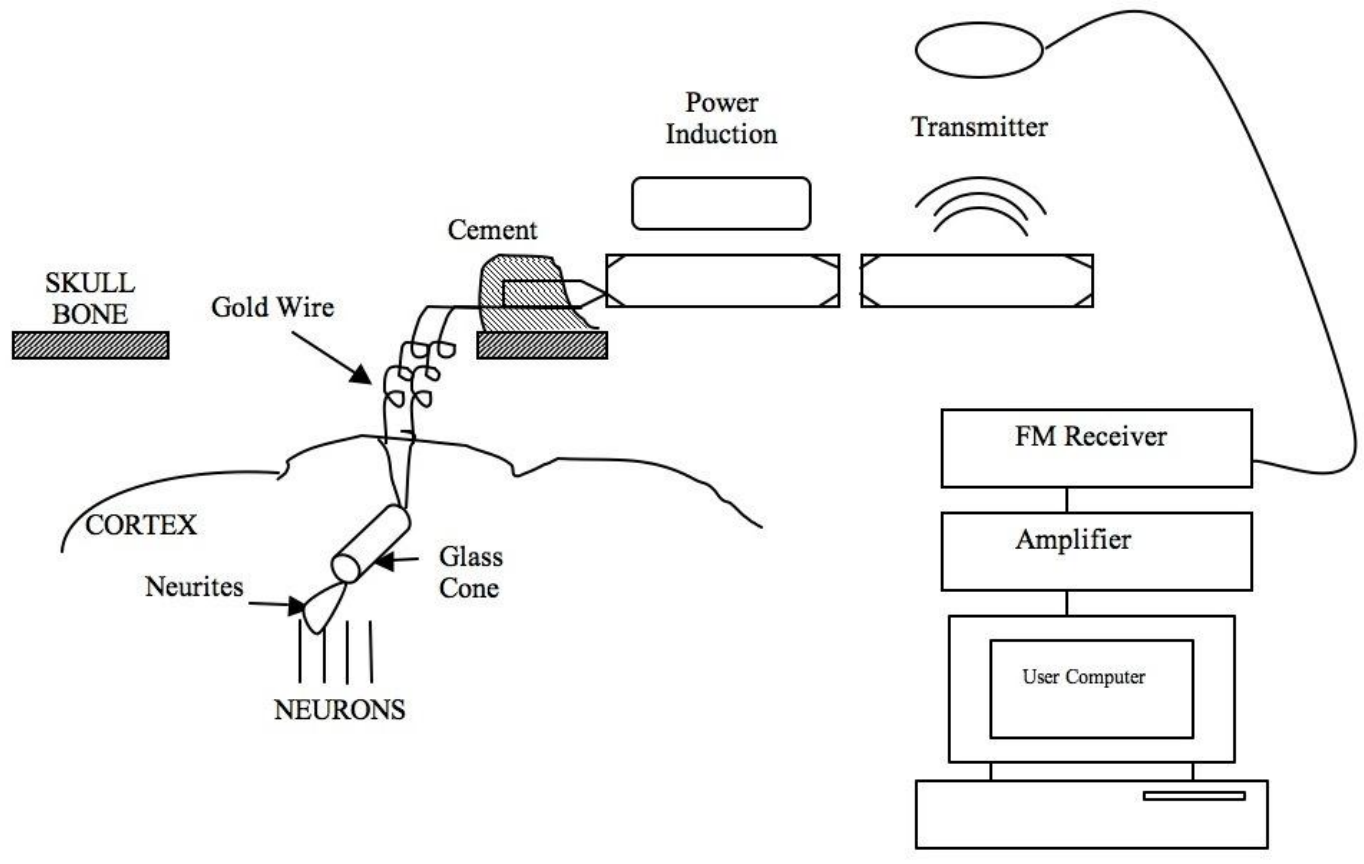


Types of Brain - Body Interfaces for Traumatic Brain-Injured

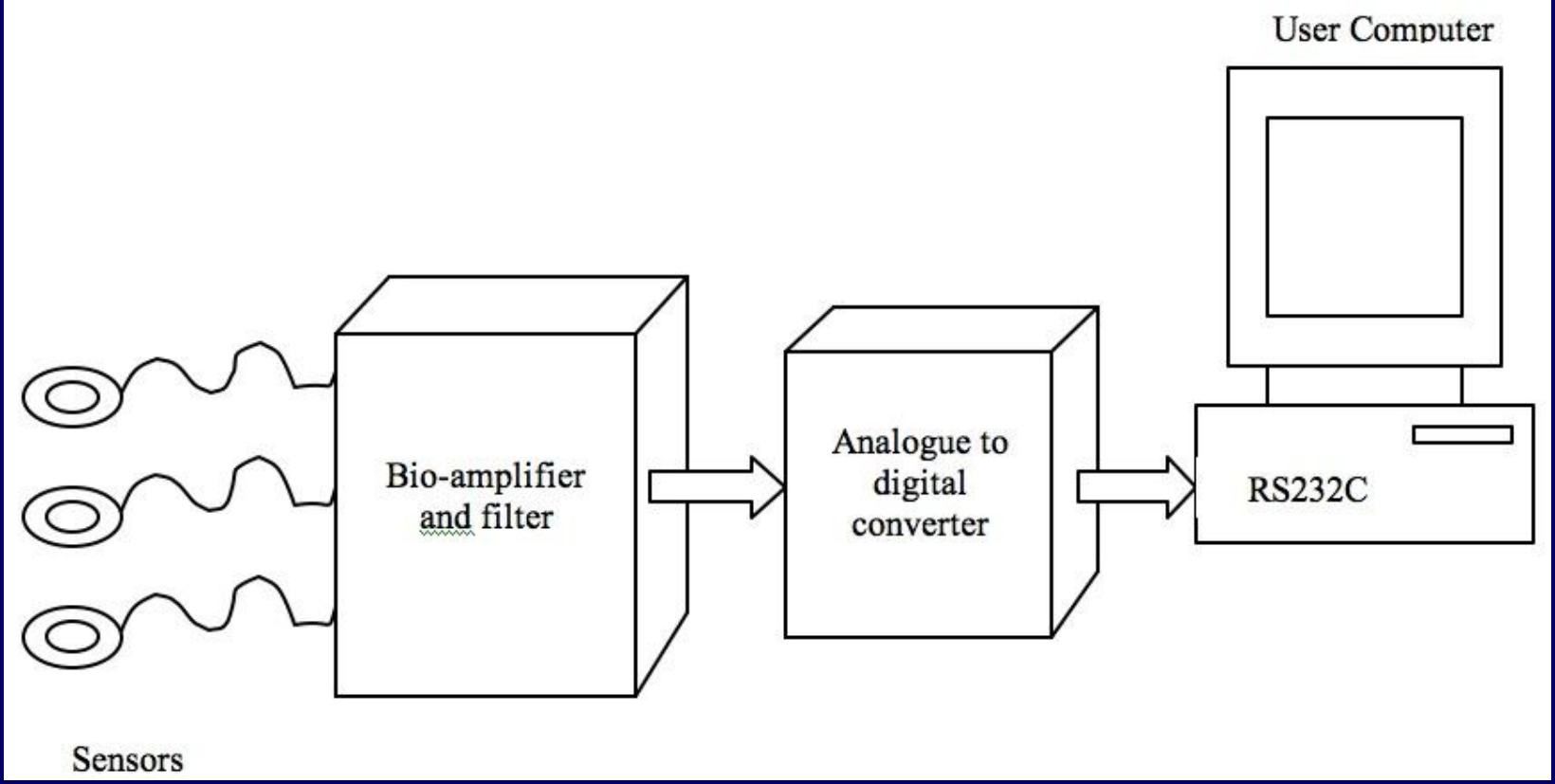
Two types:

- Invasive
- Non-invasive

Invasive BBI



Non-Invasive BBI

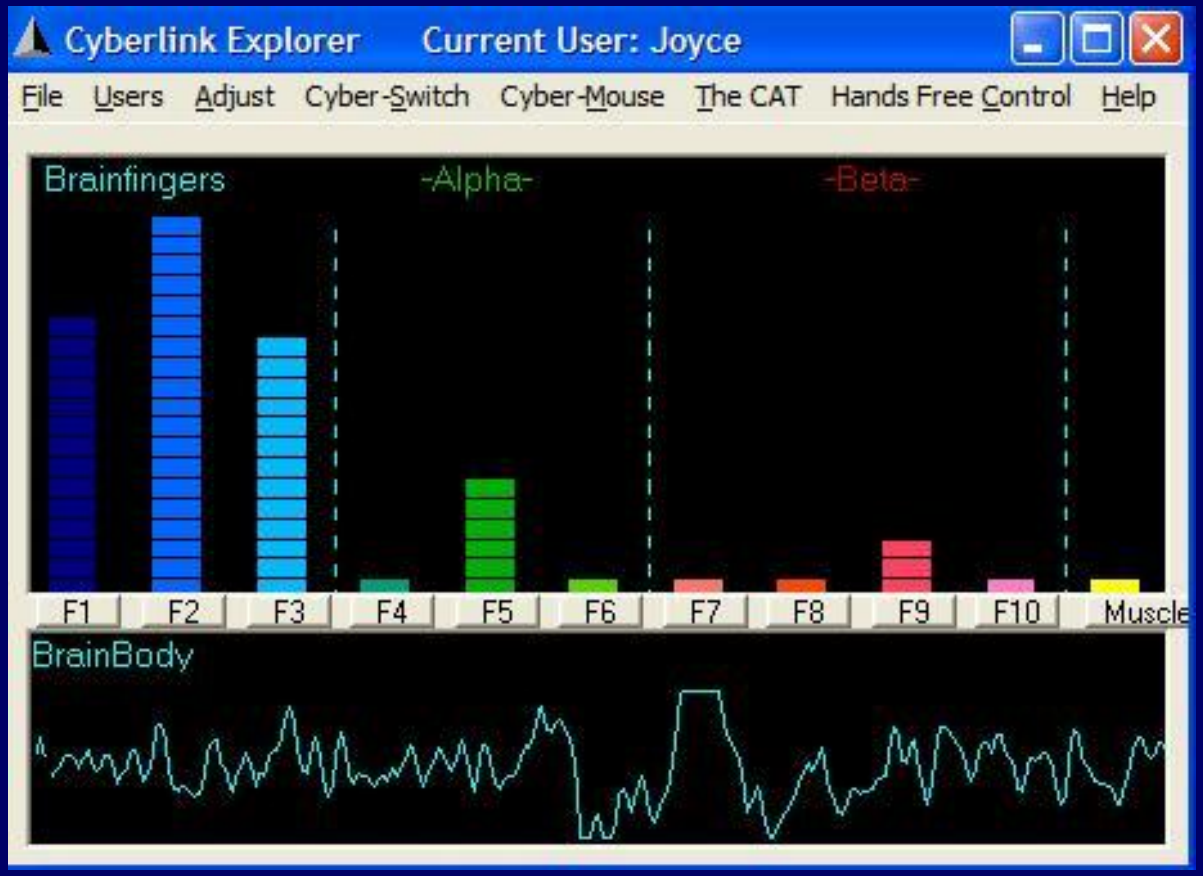


Cyberlink™

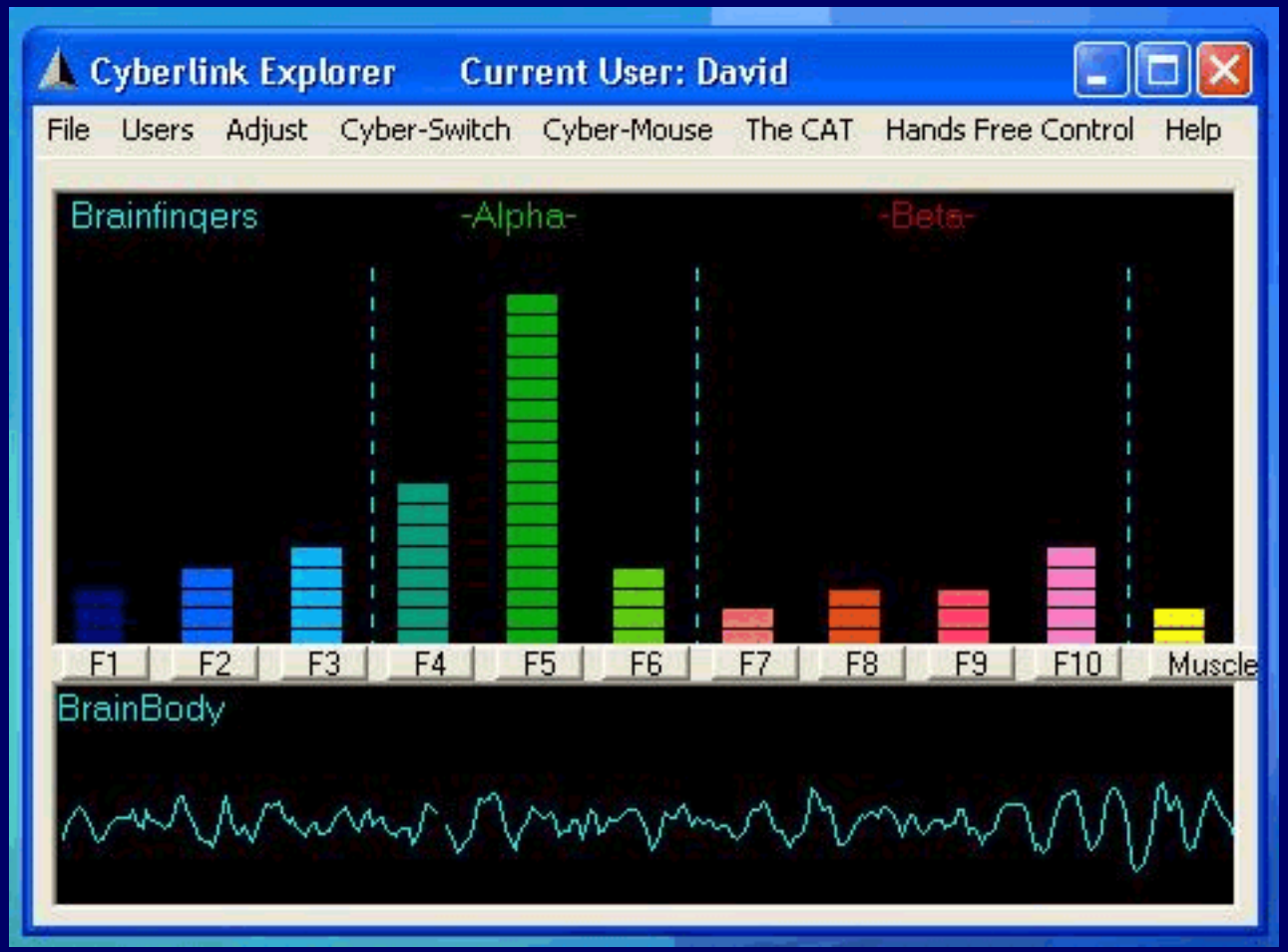
Cyberlink™ used for our research, is a non invasive brain-body actuated control technology that combines eye-movement, facial muscle and brain wave bio-potentials detected at the user's forehead. This type of interface is used for non-verbal, quadriplegic, who have no way of communicating apart from using the brain waves.

Cyberlink™ - Chosen as the best device for this research

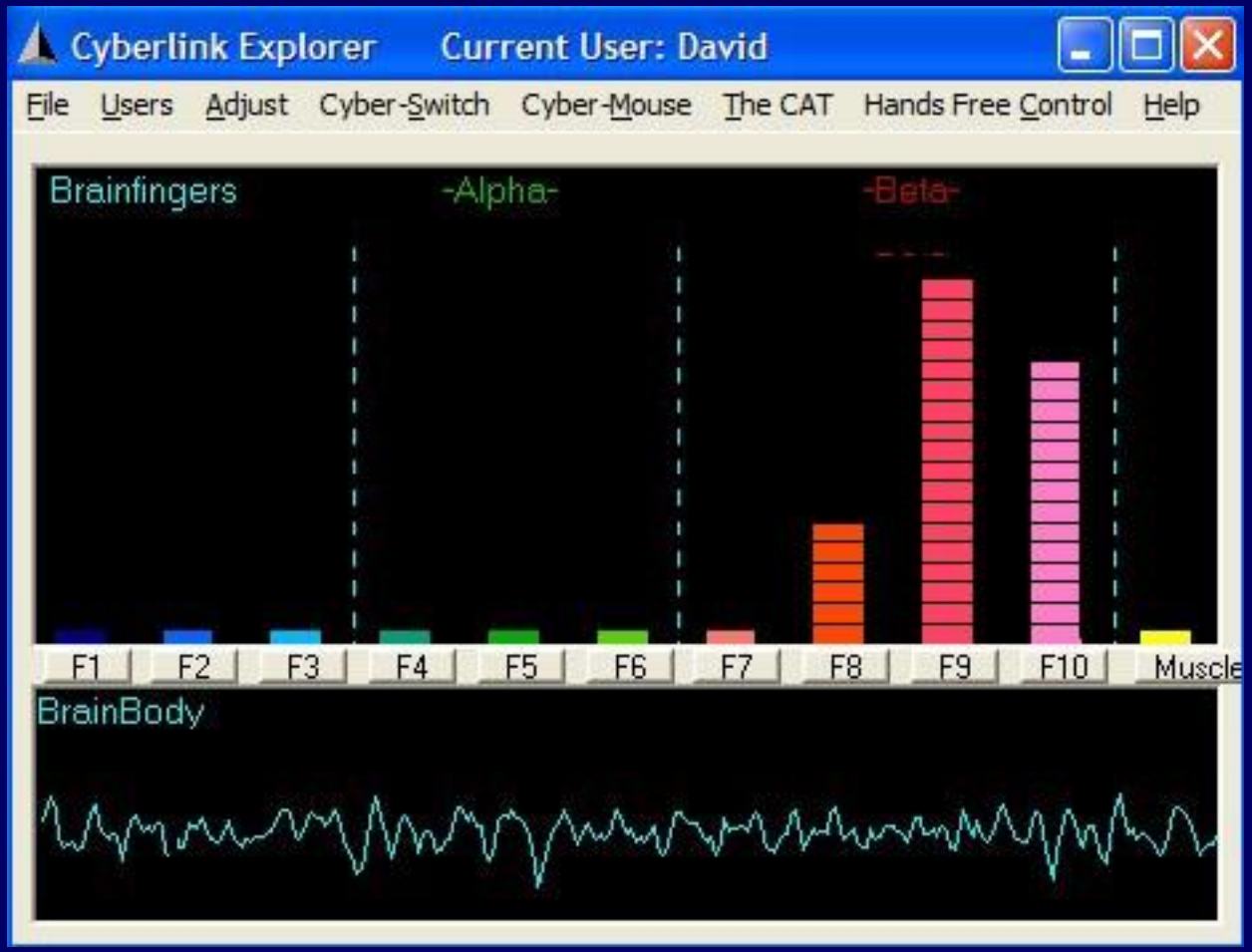
B1 thru B3 - Eye Movement



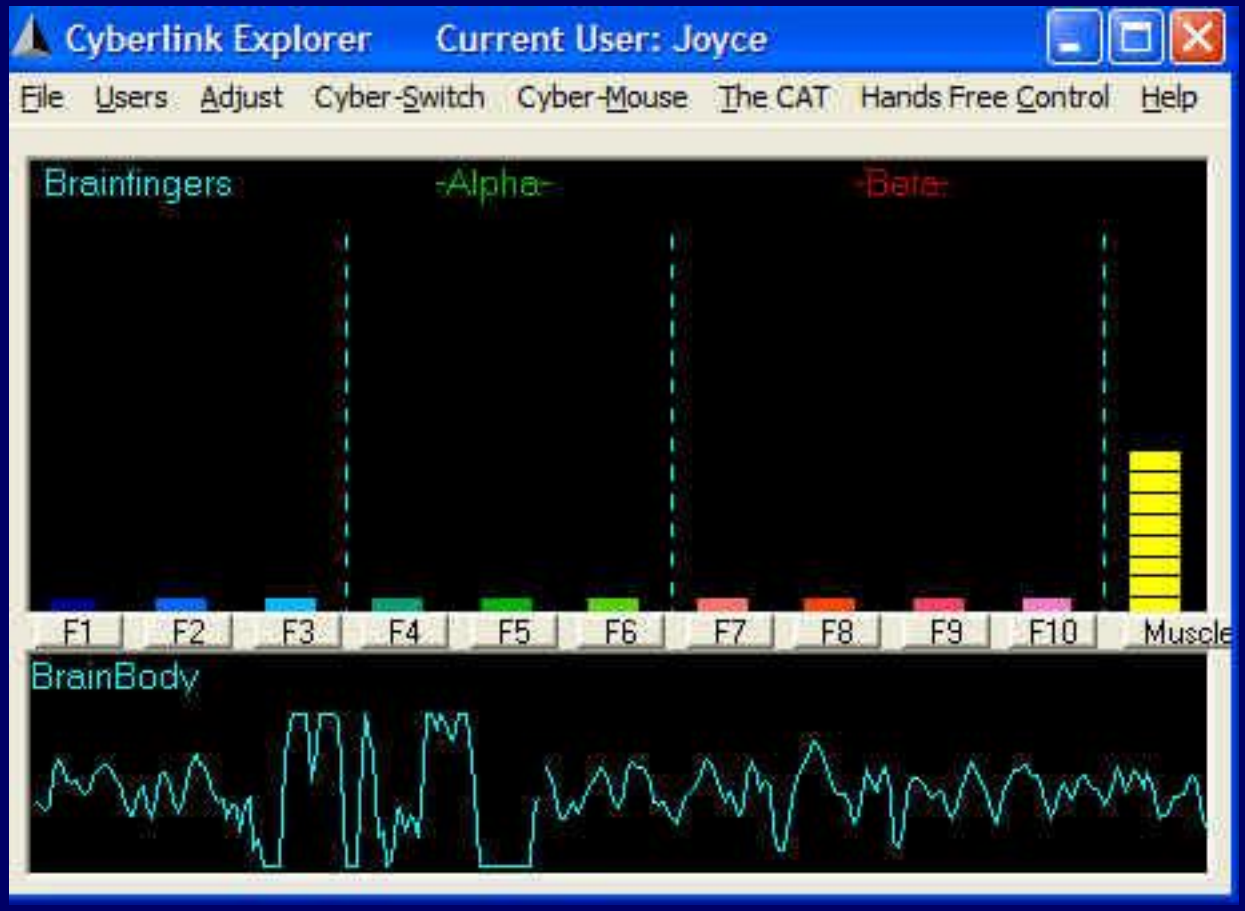
B4 thru B6 - Alpha Brain Waves



B7 thru B10 - Beta Brain Waves



B11 - Muscle


Cyberlink Explorer
Current User: Joyce
File
Users
Adjust
Cyber-Switch
Cyber-Mouse
The CAT
Hands Free Control
Help
Braintingers
-Alpha-
-Beta-
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
Muscle
BrainBody

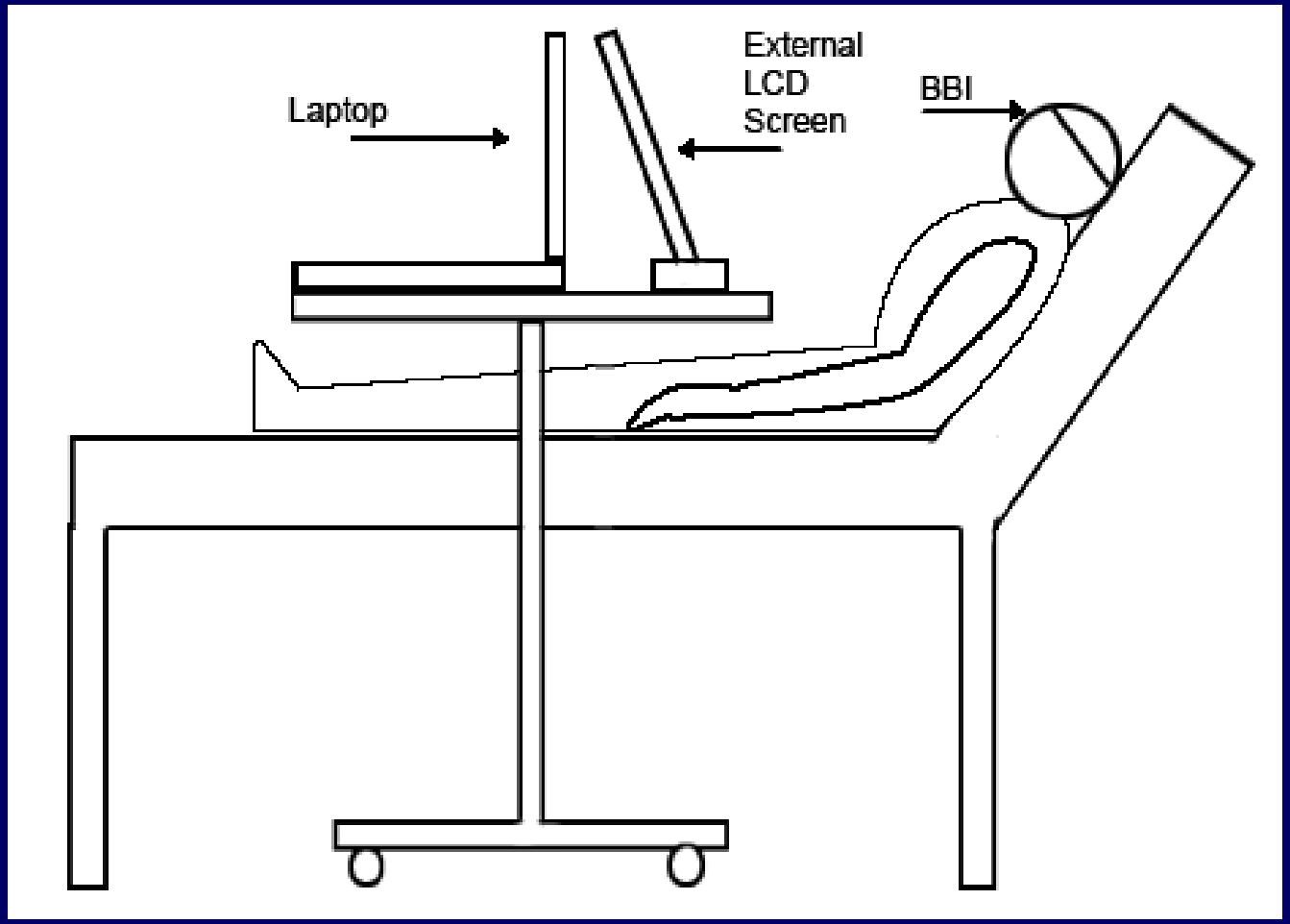
Traumatic Brain Injury and Brain-body Interfaces (BBI)

- Cyberlink can pick up various unwanted bio-potentials
- Such uncontrollable, erratic movements cause users frustration and fatigue
- Bringing the cursor back under control takes considerable effort, and may be impossible

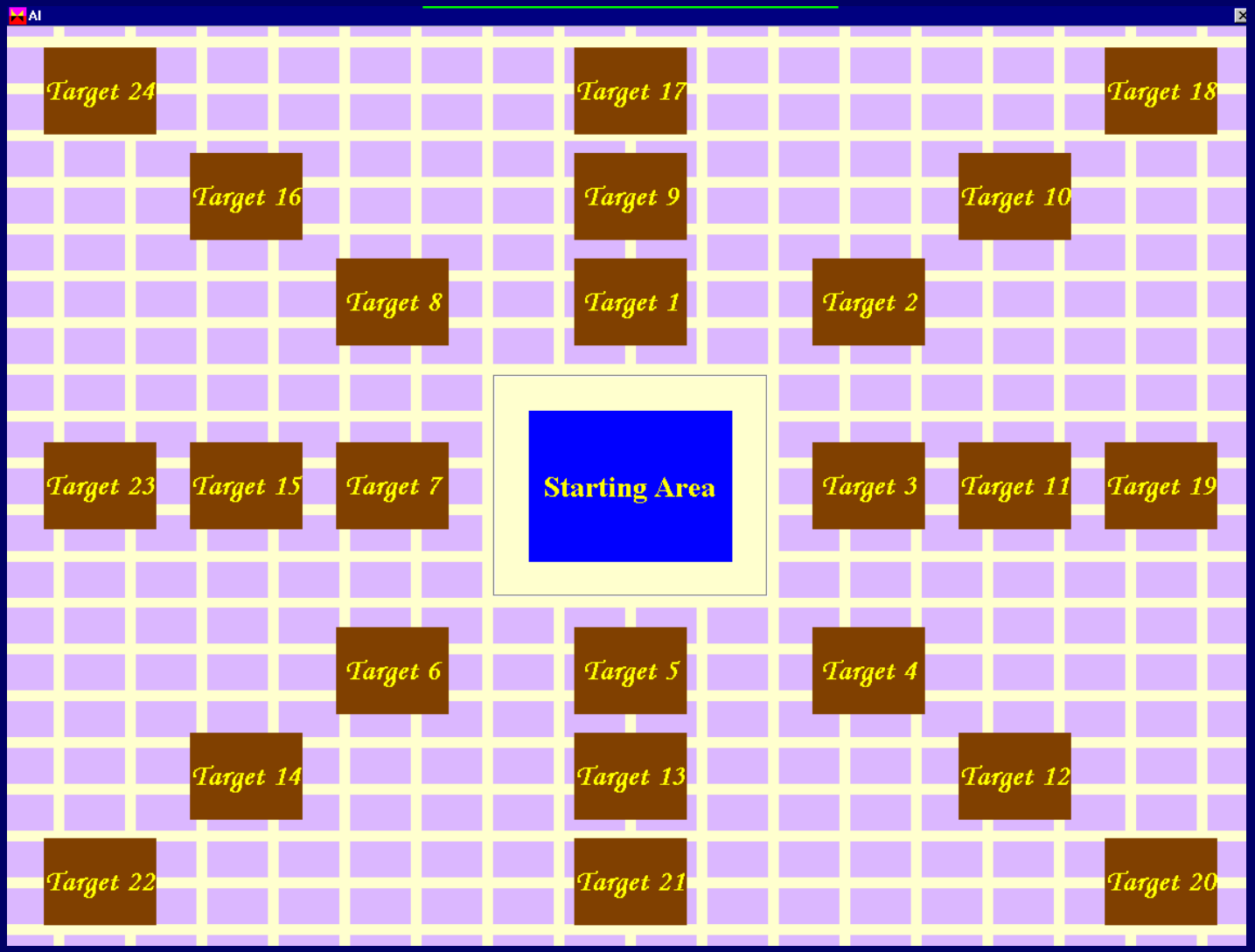
Research with BBI for the Traumatic Brain-Injured

- Issues with Brain-Injured Participants
  - Cognitive abilities are often not assessed
  - Unable to respond or really comatose
  - Difficulty of tracking participants over long periods
  - Etc.,

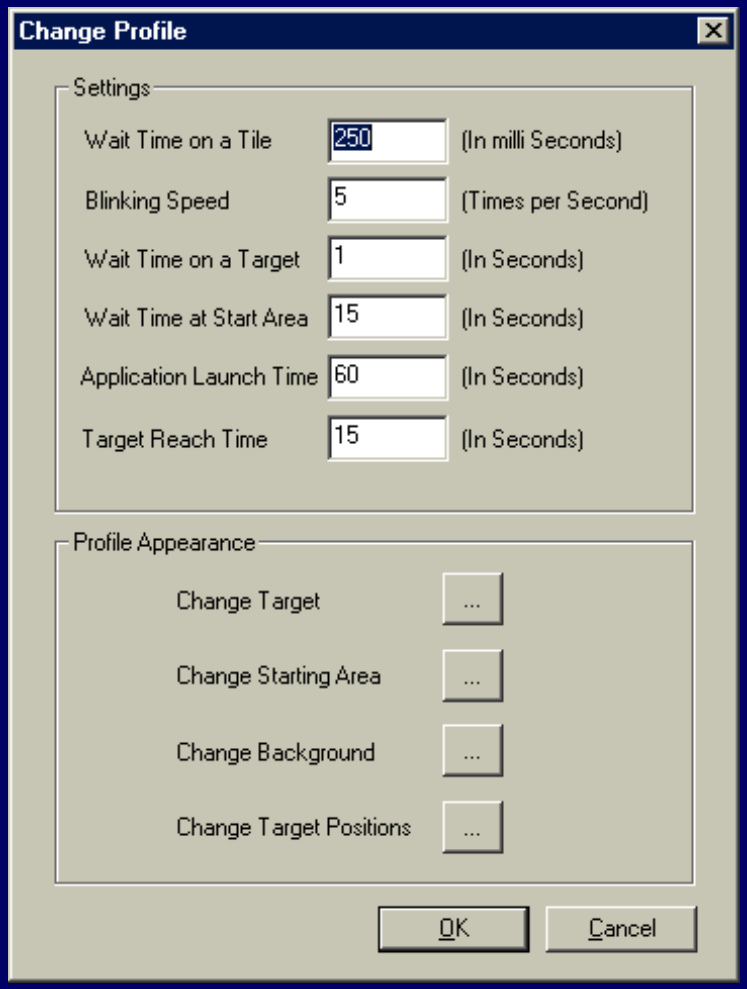
Apparatus



Personalised Tiling – Target Test



Personalisation



Personalised Discrete Acceleration interface

- Personalised interface
- Discrete Acceleration
- Programmable targets for application launch or switching devices

MIND OVER MATTER IS THE KEY TO POWERING THE LATEST MUST-HAVE GADGETS ABOUT TO HIT THE SHELVES

Thought you were in control?

BY ROB PINNIGER

A WHOLE new generation of games is about to hit the shops, with some already claiming to be the "must have" toy of the year. So, what's so special about these new gadgets? Well, they can read your mind...

Okay, we might be going over the top a little bit there but they do read your brain waves and use them to move and play. Based on the same technology used in medicine to confirm a diagnosis of epilepsy and monitor brain function — electroencephalography (EEG) — the devices feature headsets with built-in electrodes that rest on your scalp.

This lower-level EEG device uses dry electrodes to detect electrical activity in your brain and interpret it into a signal that is used to control the game.

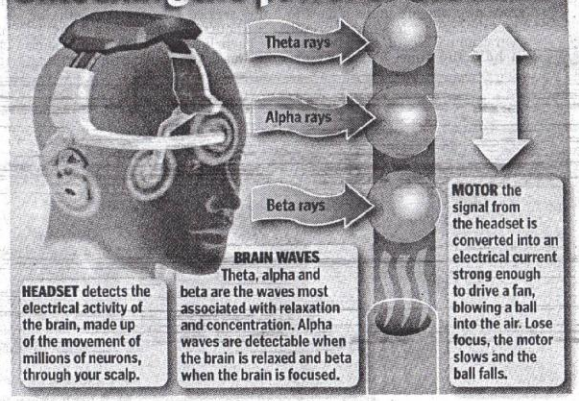
There are thought to be five different types of brain waves but the toys generally work by detecting two or three of them — alpha, beta or theta waves. The idea is to change your brain waves by either concentrating hard or attempting to relax and keep calm.

The toys can detect just how fiercely you are concentrating or how completely you are relaxing and use that information to drive the mechanism in the toy — a motor or fan for example.

As a result, higher concentration or deeper relaxation means the motor spins faster and your performance in the game is better. But be careful, as soon as you stop to think "yes, I'm winning", you lose your focus and your performance collapses.

Here we round up the pioneering games that could change the way we play...

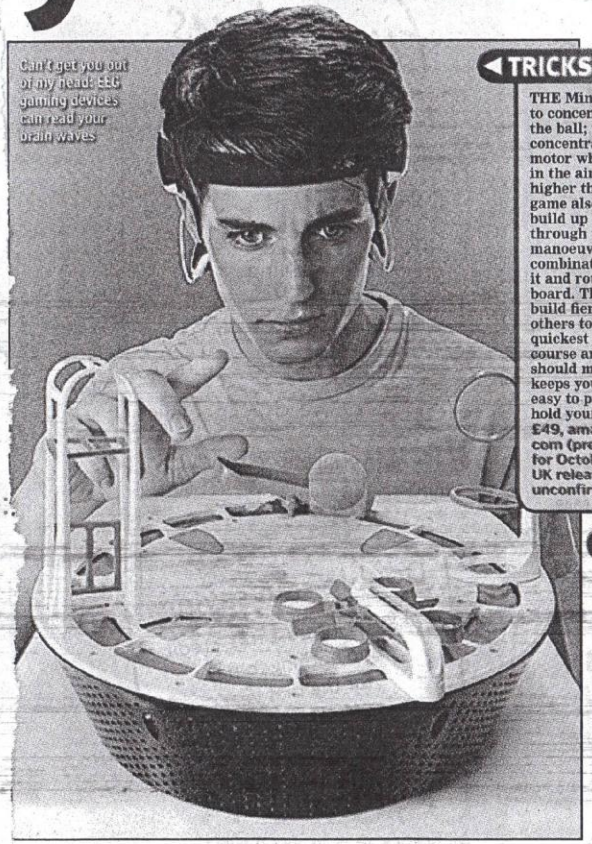
Unlocking the power of the mind



HEADSET detects the electrical activity of the brain, made up of the movement of millions of neurons, through your scalp.

BRAIN WAVES Theta, alpha and beta are the waves most associated with relaxation and concentration. Alpha waves are detectable when the brain is relaxed and beta when the brain is focused.

MOTOR the signal from the headset is converted into an electrical current strong enough to drive a fan, blowing a ball into the air. Lose focus, the motor slows and the ball falls.



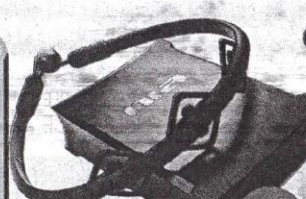
Can't get you out of my head: EEG gaming devices can read your brain waves

TRICKS OF THE MIND

THE Mindflex requires you to concentrate to levitate the ball; the harder you concentrate the harder the motor which blows the ball in the air works and the higher the ball flies. The game also allows you to build up obstacle courses through which you have to manoeuvre your ball by a combination of levitating it and rotating the game board. This means you can build fiendish courses for others to attempt, try for quickest times around the course and so on, which should mean that the game keeps you amused. It's fun, easy to pick up and will hold your interest.

£49, amazon.com (pre-order for October, UK release unconfirmed)

9/10



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NEURAL PC

THE NIA, or Neural Impulse Actuator, is a headset designed to connect to your PC to allow you to control games without the use of a mouse or keyboard. That sounds pretty revolutionary but don't expect to sit at your desk thinking "move left", "swap weapon" and so on. You will need to assign certain muscular motions and mental states to specific game actions. For example, raising your eyebrows might be "fire" and concentrating might move your character forward. It requires extensive calibration and training but for serious gamers, the reward of fast reaction times can be worth it.

£79.99, amazon.co.uk

JEDI MIND CONTROL

THE idea with the Star Wars Force Trainer is to achieve higher and higher levels of concentration in order to move the Jedi Training Remote up and down the Training Tower. It's easy to get it going but if your concentration weakens, the ball drops back to the bottom. There are 15 levels of difficulty, with all interaction voiced by Yoda. It's fun, until the novelty has worn off.

£99.99, funfilledtoys.co.uk (Pre-order for delivery next month)

6/10

REFLEX GAMING

SIMILAR to the NIA, the Emotiv EPOC is a control system for PC games. It uses 14 electrodes, compared with NIA's three. The extra hardware means that the EPOC is likely to offer finer levels of control but could also mean a longer period of training before you can use the device. Emotiv has decided not to sell the headsets direct to the public but instead to license them to game developers to be integrated into future releases.

£304 for a programmer's development kit, emotiv.com

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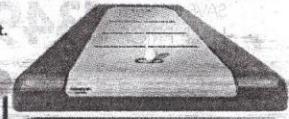

BRAIN WAVE RACE

MINDBALL is a serious bit of kit and the price (£11,365) reflects this. It's a table, along which runs a track. You sit at the end of the table and attempt to move a ball along the track, forcing it closer to your opponent by relaxing your mind. The more you relax, the further it goes. The device comes with a monitor that shows measured brain waves and claims it has the health benefit of teaching you how to overcome anxiety. Intended more for exhibitions.

£11,365, or £595 to hire, vivifeye.com/mindball/index.html

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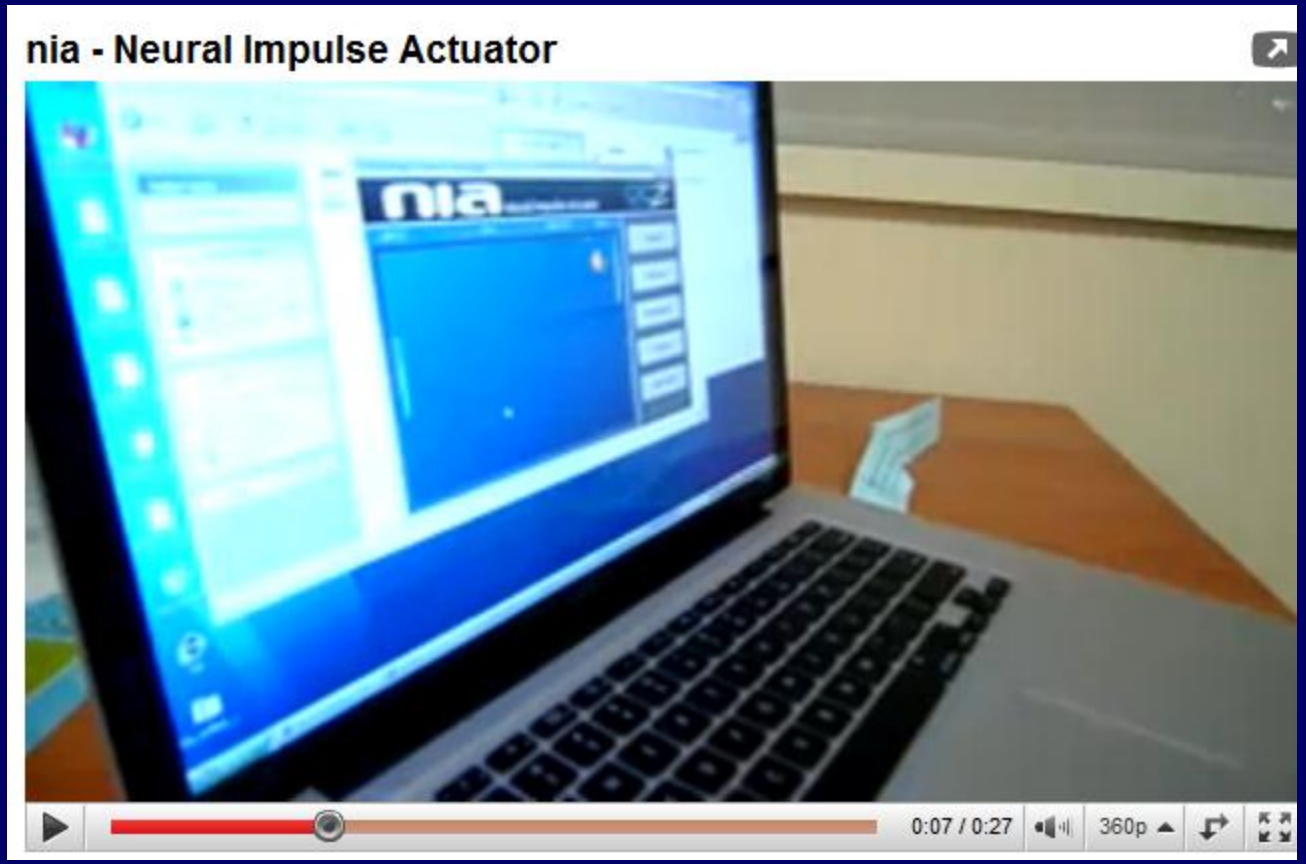
Cyberlink

http://www.youtube.com/watch?v=ZKA2-zvinQc&feature=related

OCZ NIA Neural Impulse Actuator



http://www.youtube.com/watch?v=P0Nvlk-tTVk

Neurosky

http://www.youtube.com/watch?v=wNr3yGcI_V8&feature=related

Other Brain Computer Games Consoles

Mind Balls
Mind Flex
Jedi Mind Control

Any Ideas for collaborative Research?

Possible Future Research Opportunities

- Using Bio-Potentials as a diagnostic tool
- Rehabilitation games for brain injured
- Designing Interfaces to existing applications using BCIs
- Accessing web applications using bio-potentials
- Using a BCI to control a robot

Possible Future Research Opportunities

- Designing an interface that can detect a range of bio-potentials, so that the appropriate/available one for that particular brain injury, can be chosen for the BCI
- A BCI that had probes that can fit in any part of a body to obtain bio-potentials not just from the head

Any Questions?